The Ario Dowsing Experiment, Picos de Cornion, Spain, 2005

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Introduction

The idea for the Ario dowsing experiment was quite simple – to get as many members of the 2005 OUCC Expedition as possible (irrespective of dowsing belief or ability) to record, using GPS, the location of their (on and off) dowsing responses along a well-defined path. The path could be walked in either direction and at any time. It seemed possible that this simple plan might gain enough data from a variety of subjects to begin to answer some of the thorny questions of dowsing, viz.:

1. How repeatable is a dowsing trace by one person, and how well does a dowsing trace correlate with dowsing traces produced by different people?

2. How “sensitive” are different people, e.g. is dowsing ability affected by the sex or other characteristics of the subjects? It was not intended to go further into the big questions of “what does dowsing show” and “how does dowsing work” in this exercise. A reasonably well-defined path contouring around the Ario bowl was chosen as an easy-to-follow circuit. Although there were already published dowsing results covering the area (Wilcock, 1991, Figure 1 below), they were not obtained by walking the chosen path, few of the participants could be expected to remember them or to relate them easily to the circuit, and they were not available at the expedition site. Also, the participants did not watch each other, and the results were not processed on site.

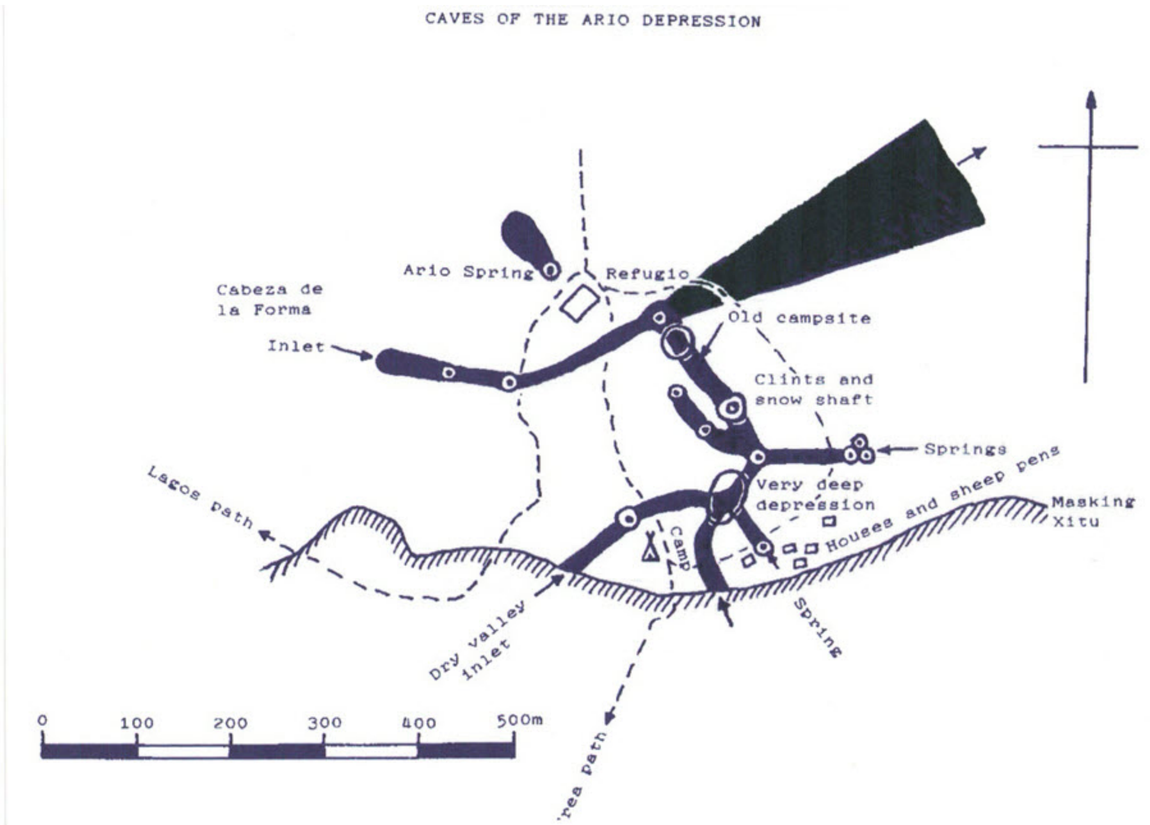

Figure 1. The Ario Bowl, showing previous dowsing reactions (Wilcock, 1991), and the track around the bowl that was used for the Ario Experiment in 2005

Raw Data

Figure 2 is a straight plot of dowsing reactions for the 16 individual runs (12 males, 1 female), one person having three runs, and another having two runs, for comparisons of consistency and repeatability. For those participants undertaking more than one run, at least one run was clockwise around the Ario Bowl, and at least one was anticlockwise. This shows that one participant (16) had no reactions at all, while the other participants ranged from only one reaction (4) to some being decidedly sensitive, with very many reactions (e.g. 12, 14).

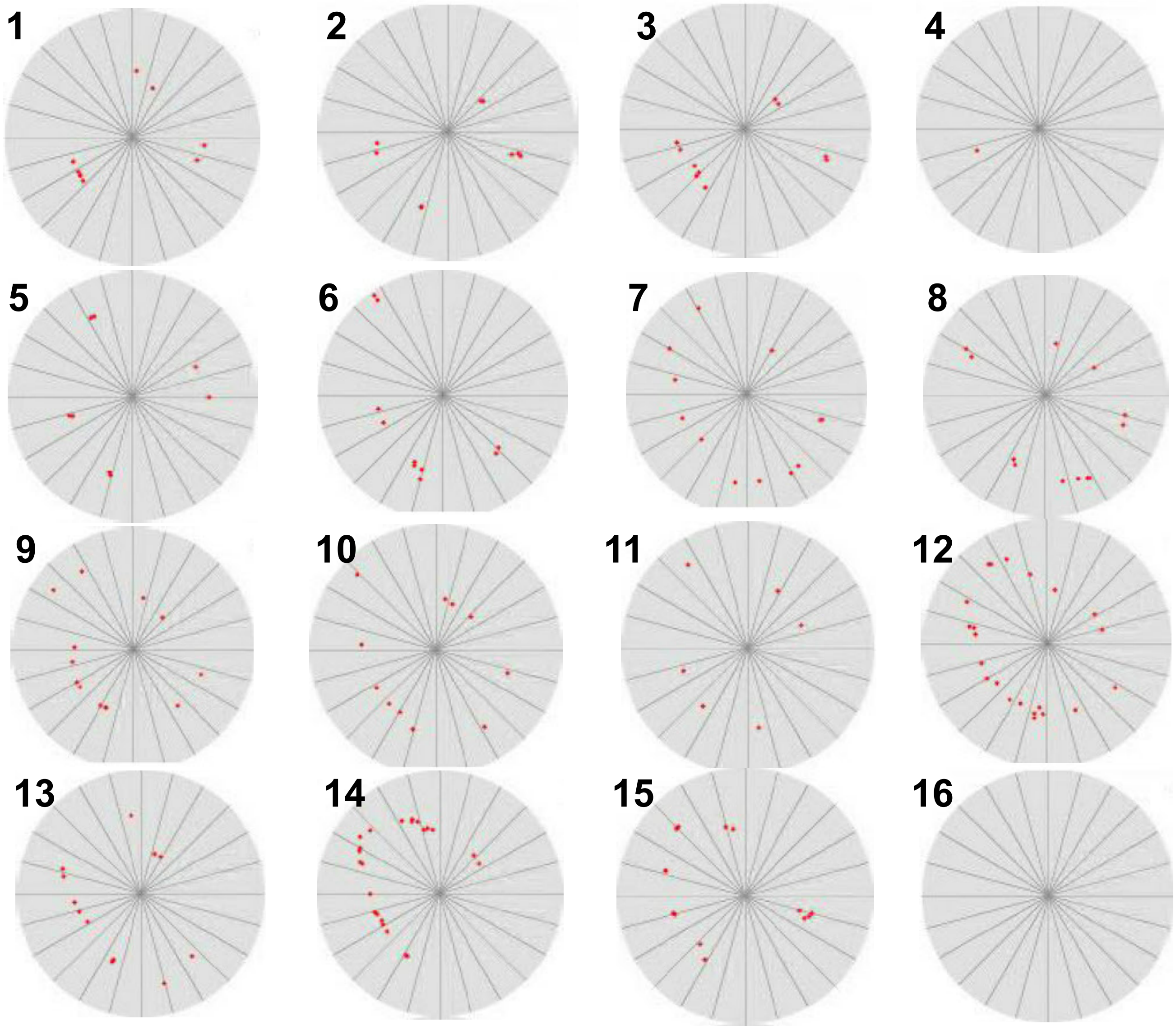

Figure 2. Plots of individual dowsing reactions for the subjects, showing the boundaries of the 24 selected 15-degree segments used for standardising the data

Figure 3 is a total plot of all dowsing reactions obtained. Visual comparisons of the raw data seemed to indicate some similarities in the pattern of reactions.

Figure 4 is a bar chart of the 24 15-degree segment counts for all subjects. The red bars are unprocessed raw data. The blue bars are processed "Bar Code" (presence/absence) data with multiple reactions in the same segment normalised to one reaction per participant having a positive reaction in that segment. The heights of these bars for the segments gives an indication that, far from there being a random distribution of reactions (which would tend to give equal bar heights), some segments are very much more reactive than others. All subsequent analyses in this paper use the normalised data with multiple reactions normalised to one reaction per segment per practitioner.

However, it was agreed that a more rigorous approach was required, and it was decided to attempt further analysis using the well-known *Weighted Pair Group Average Link Cluster Analysis* and *Principal Components Analysis* algorithms.

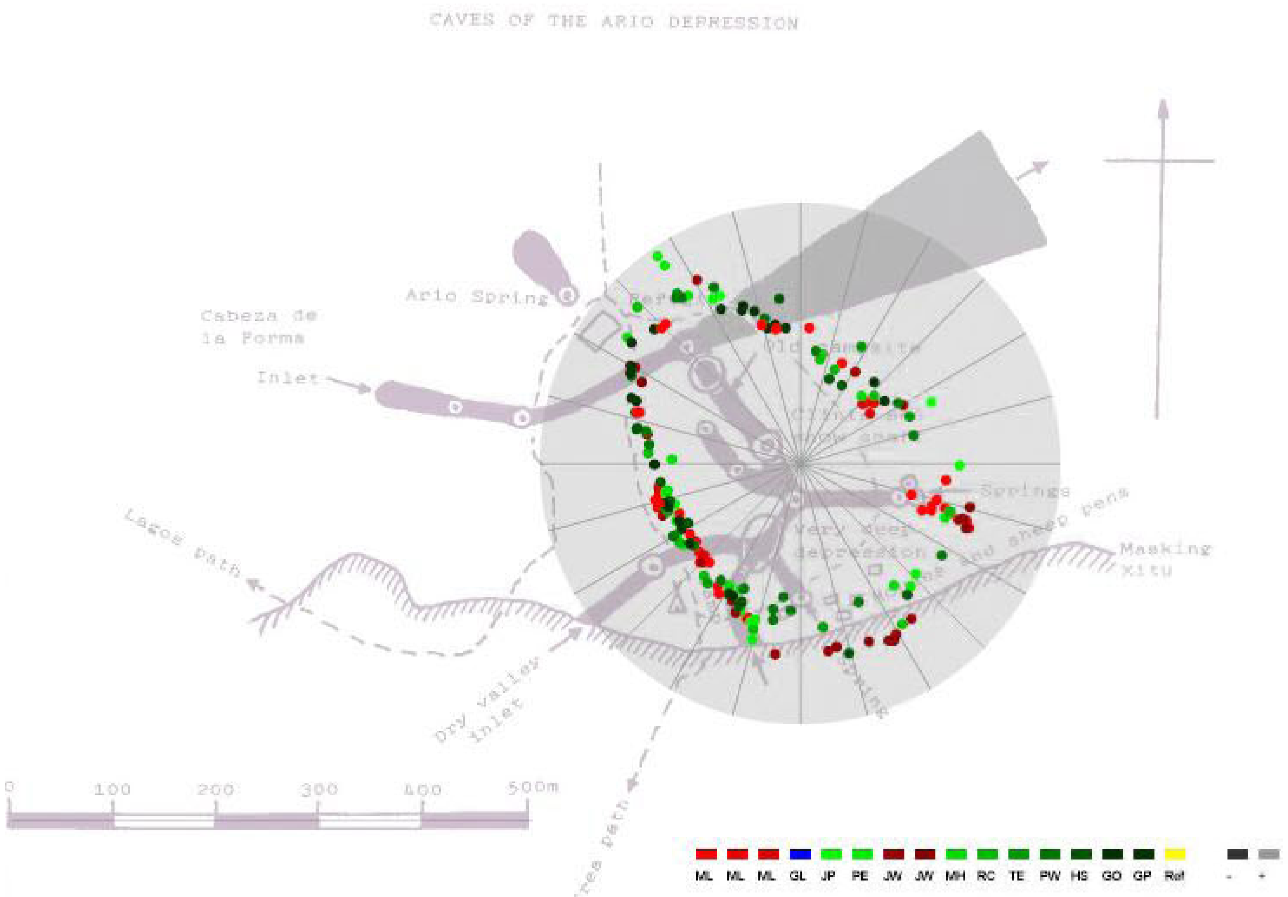

Figure 3. Total dowsing plots for all subjects along the track around the Ario Bowl, superimposed on the previously-published dowsing results

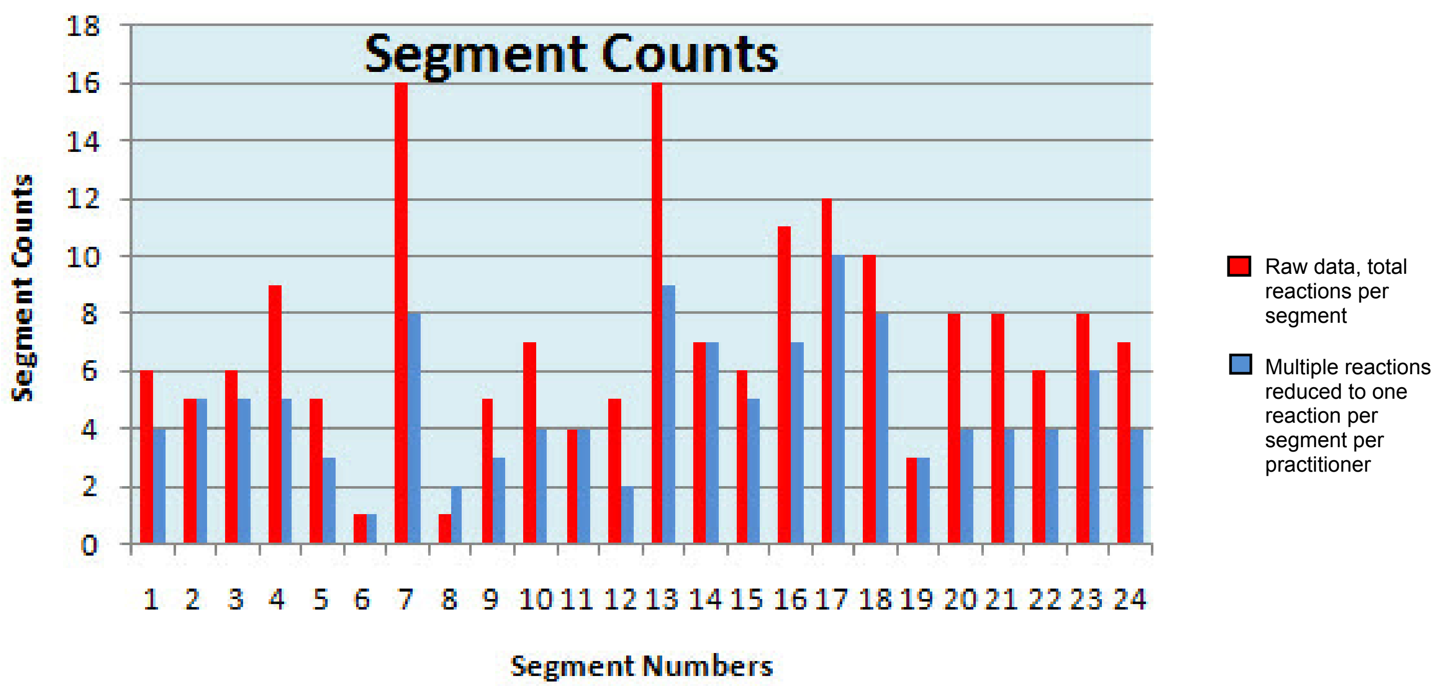

Figure 4. Bar chart of the 24 15-degree segment counts for all subjects, red = raw data (some with many reactions in the same segment) , blue = "Bar Code" processed data (with multiple reactions in the same segment normalised to one reaction per segment per practitioner.

Basic Processing

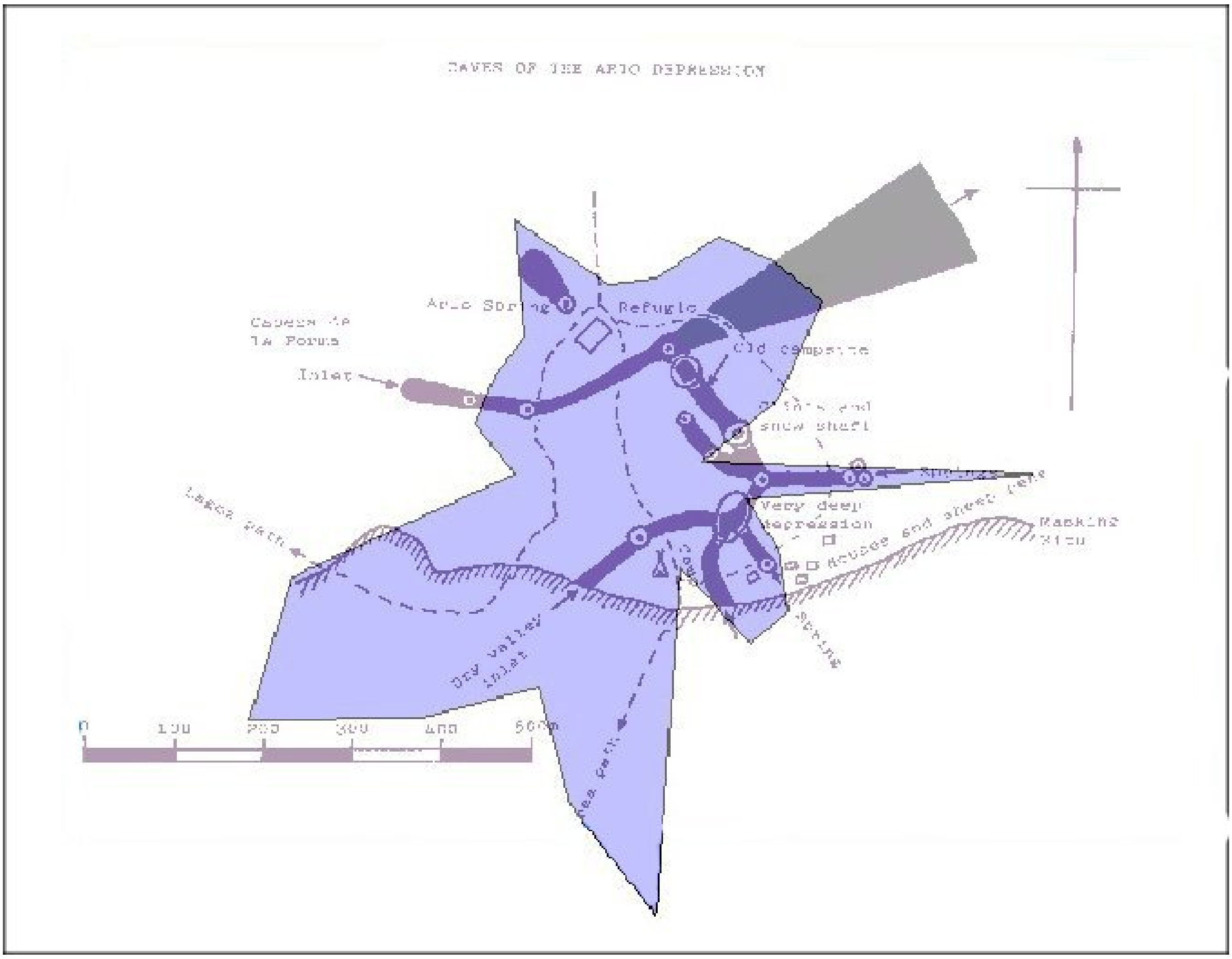

Figure 5. Segment radar plot for processed data . Note the very sharp eastern peak for the (dry) Shepherds' Spring, and lobes for the Xitu reaction (S), the dry valley (SW), Ario Spring(NNW) and the supposed Cabeza Muxa outflow (NE).

A radar plot (so-called because it resembles a scanning radar display on a plan position indicator) portrays the bar chart heights in their respective segments as radial displacements from the centre of area. For random data, for which the bar chart heights would tend to be equal, the radar plot would be a jagged 24-point star. For a very large random sample without segmentation it would approximate to a circle. Figure 5 shows the radar plot for the experimental data superimposed on the previously published dowsing reactions. Clearly the results are non-random, and the bulging lobes (highest segment counts) in the radar plot in general correspond with previously detected reactions, which appear to relate to caves. These are, clockwise from true north:

- Possible outlet NE from the Ario Bowl to the Cabeza Muxa System
- A very dramatic spike corresponding to inflow from the (dry) Shepherds' Spring (E)
- Two inlets from the SE near the shepherds' huts
- Heavy reaction towards Xitu (S)
- Heavy reaction for the dry valley inlet from the SW
- Slight reaction for a W inlet, corresponding with a previously dowsed feature
- The Ario Spring reaction (NNW).

Cluster Analysis

It was thought that if the reactions were noted as hits in particular segments of the 360-degree circuit, then a “bar code” might be derived for each practitioner (Figure 6), as a basis for further computer analysis. As a by-product of this form of presentation, the numbers of positive reactions obtained in each of the 15-degree segments over the whole experiment is also shown in Figure 6, both as a “shaded” pattern with colours conventionally used to indicate height above sea level on maps, and as a “gradient profile” or section. It is clear from this that the reactivities of the sectors are not all equal - some sectors receive a high count while others have a low count.

0	1	1	0	0	0	1	0	0	0	0	0	0	0	1	1	1	0	0	0	0	0	0	0	ML1
0	0	0	1	0	0	1	0	0	0	0	0	1	0	0	0	1	1	0	0	0	0	0	0	ML2
0	0	0	1	0	0	1	0	0	0	0	0	0	1	1	1	1	1	0	0	0	0	0	0	ML3
0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	GL
0	0	0	0	1	1	0	0	0	0	0	0	1	0	0	0	1	1	0	0	0	0	1	1	JP
0	0	0	0	0	0	0	1	0	0	0	0	1	0	0	0	1	1	0	0	0	0	1	0	PE
0	0	1	0	0	0	1	0	1	1	1	1	0	0	1	0	1	0	0	1	1	0	1	0	JW1
0	1	0	0	0	0	1	0	0	1	1	0	1	0	0	0	0	0	0	0	1	0	0	0	JW2
0	1	0	1	0	0	1	0	1	0	0	0	1	1	0	1	0	1	1	0	0	1	1	0	MHo
0	1	1	1	0	0	1	0	0	1	0	0	1	1	1	1	0	0	1	0	0	1	0	0	RC
0	0	1	0	1	0	0	0	0	0	1	0	0	1	0	0	1	0	0	0	0	0	1	0	TE
1	1	0	0	1	0	0	1	0	1	0	1	1	1	0	1	1	0	0	1	1	0	1	1	PW
1	0	1	0	0	0	0	0	1	0	1	0	1	0	0	1	0	1	0	1	0	0	0	0	HS
1	0	0	1	0	0	0	0	0	0	0	0	1	1	0	1	1	1	1	0	1	1	0	1	GO
1	0	0	0	0	0	1	0	0	0	0	0	0	1	1	0	0	1	0	1	0	1	0	1	GP
0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	MHi
4	5	5	5	3	1	8	2	3	4	4	2	9	7	5	7	10	8	3	4	4	4	6	4	

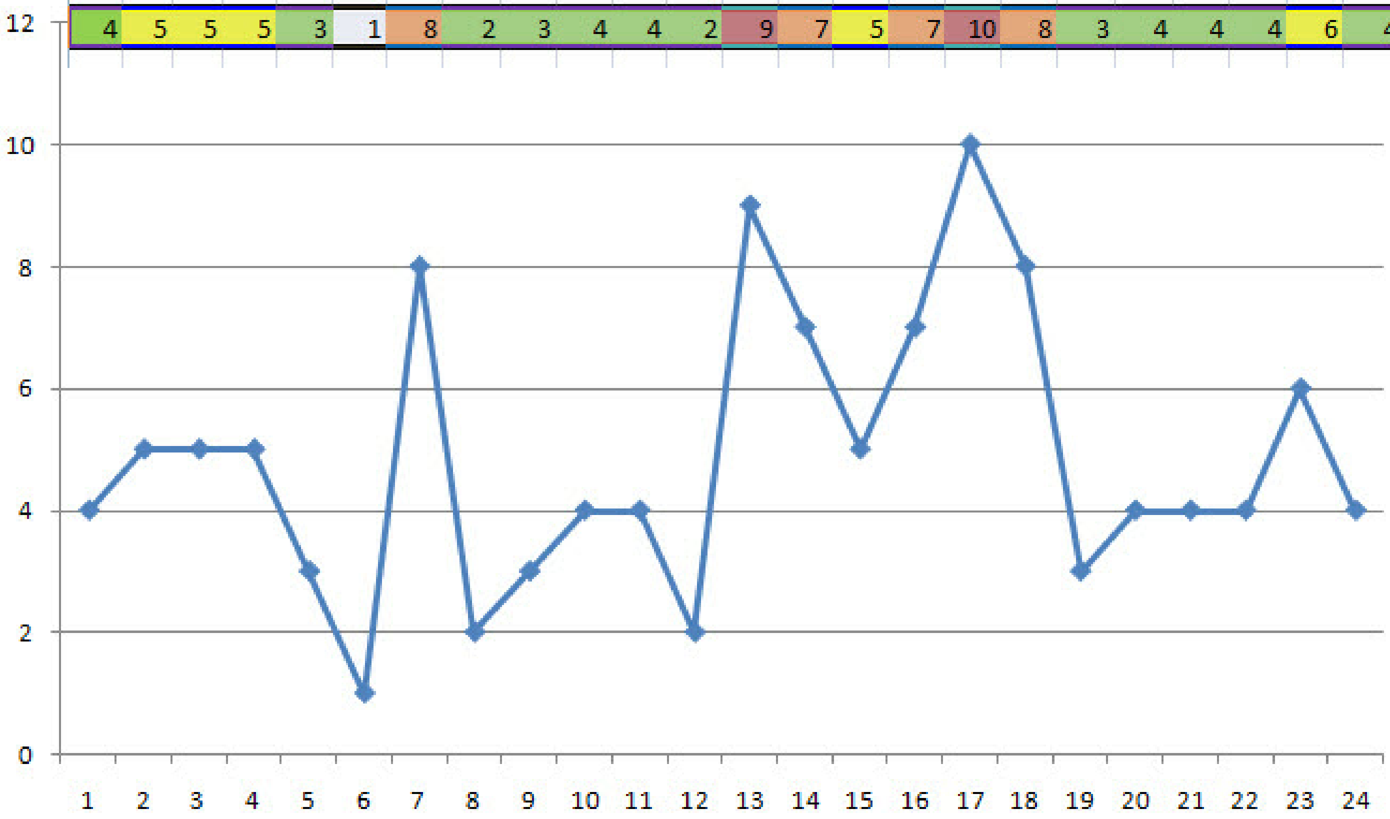

Figure 6. “Bar Code” representation of the zones in which dowsing reactions were observed by the practitioners in the 24 15-degree segments selected for standardisation of the data

It was also thought that cluster analysis properly used should at least be able to discriminate between experienced dowsers, neophyte dowsers and practitioners showing little aptitude for dowsing. Furthermore, it was hoped that the analysis of several reliable dowsers would reveal that the observations were repeatable and consistent, and moreover these would correspond with already published results (Wilcock, 1991).

Statistical analysis has long been facilitated by the use of computers. The second author has long experience in this field (see References in Appendix 1) and developed his own software in the late 1960s, originally using the Algol60 programming language. Various standard implementations of *Weighted Pair Group Average Link Cluster Analysis* and *Principal Components Analysis* are now available as freeware. After many changes of computer hardware and operating systems, some features of the original software have been implemented in Excel.

It was necessary to present the data to the computer in the same standard form for each practitioner. As a first step all the GPS readings were averaged to find the centre of area of the region (the readings should all have been paired "on " and "off": where an odd number was found it was assumed that the reaction had minimal width, so the corresponding reading was duplicated). It was decided to split the 360 degrees of the circuit into 15-degree segments, numbered from segment 1 (the first segment NNE of true north) clockwise to segment 24 (the last segment immediately NNW of true north). Of course some of the segments so defined did not have any dowsing reactions, so for these segments the coordinates of the centre of area were entered. For segments with multiple dowsing reactions the readings were averaged. This gave an equal number of 24 eastings/northings pairs (a total of 48 readings representing a sort of "GPS bar code") for all 16 runs – this was the raw data submitted to the cluster analysis procedure.

The next problem was what type of cluster analysis to employ, numerous different mathematical routines being available. Hierarchical cluster analysis creates a hierarchy of clusters which may be represented in a tree structure called a *dendrogram* (see Lock & Wilcock, 1987, p.37). The "root "of the tree consists of a single cluster containing all observations, and the "leaves" correspond to individual observations, while the linking of branches define successively larger clusters (also called groups or phenons). The use of the term "*phenon*", or its derivative "*phenotype*", is commonly used in biometric analysis, e.g. the groups which have been formed at say the 70% similarity level may be referred to as the 70% phenons. A common algorithm for hierarchical clustering is referred to as *agglomerative*, i.e. forming larger and larger clusters as the similarity is reduced. Any valid metric may be used as a measure of distance or similarity between pairs of observations. The choice of which clusters to merge is determined by a linkage criterion, which is a function of the pairwise distances between observations.
What constitutes a valid procedure has been argued about over many years by numerous mathematicians, some claiming that single link cluster analysis is the only valid method, despite its notorious "chaining" in the results. The experiences of the second author over several years of data analysis had been that *Weighted Pair Group Average Link Cluster Analysis* gave the most useful and explainable results for archaeological and other physical data, so that was the method employed for analysis of the dowsing experiment data. Within this method several other decisions have to be made. The first decision is what type of data is to be used:

- raw data

- normalised data, i.e. processed according to mean and standard deviation of each property: this is to prevent properties with high numerical values swamping properties with low numerical values, and the result is to give all properties the same weight in the analysis

- data with the values normalised as percentages of the largest property value for each individual property: the numerical values are replaced by percentages

- data with the values normalised as percentages of a total of the properties within a sample: the numerical values are replaced by percentages of the total

- data with the values normalised as percentages of the maximum property value over all the samples: the numerical values are replaced by percentages of the maximum property value

The second decision is the procedure to be used:

- Q (sample v sample) analysis, or

- R (property v property) analysis.

In this case the decision was made to use Q analysis of raw data. The *minimum spanning tree* was derived (the simplest linkage between the most similar items: branches are allowed but no loops, see Lock & Wilcock, 1987, p.45), and finally cluster analysis was performed using the selected method, resulting in groups of items being formed at particular phenon percentage similarity levels. *Dendrograms* and *Wroclaw diagrams* (named after the place where they were first used by a Polish mathematician, see Lock & Wilcock, 1987, p.47) were then produced. See Appendix 1 for a worked example and additional references.

Principal Components Analysis

An alternative data form, "*presence/absence bar codes*", was also tried, indicating only presence (1) or absence (0) of a dowsing reaction in each of the 24 segments, a total of 24 readings per practitioner. The results of the cluster analysis using binary bar codes were similar to the results using GPS bar codes. *Principal Components Analysis* was also attempted: in this form of analysis it is the properties rather than the samples that are under investigation, and the properties are effectively clustered. New synthetic dimensions (*Principal Components*) are then calculated which combine features of many of the original properties, explaining the variance with fewer properties. In the presence/absence bar codes case with 24 properties it was found that 15 such principal components explained more than one property's worth of the variance, totalling almost 95% of the variance, the first principal component explained almost 10% of the variance, and the second more than 7% of the variance. It was found that the synthetic properties providing the most significant discrimination were reactions in:

- Segments 7 (Shepherds' Spring) and 15 (SW inlet) occurring together
- Segments 19 (W inlet), 21, 22, 23 (Ario Spring), 24 and 2 occurring together.

Using these first two principal components (synthetic properties) as x and y axes, a plot of the samples (individuals) can then be made. The minimum spanning tree can also be added to such a diagram. Also the groups derived in the minimum spanning tree can be added as loops around the nodes, producing a Wroclaw Diagram.

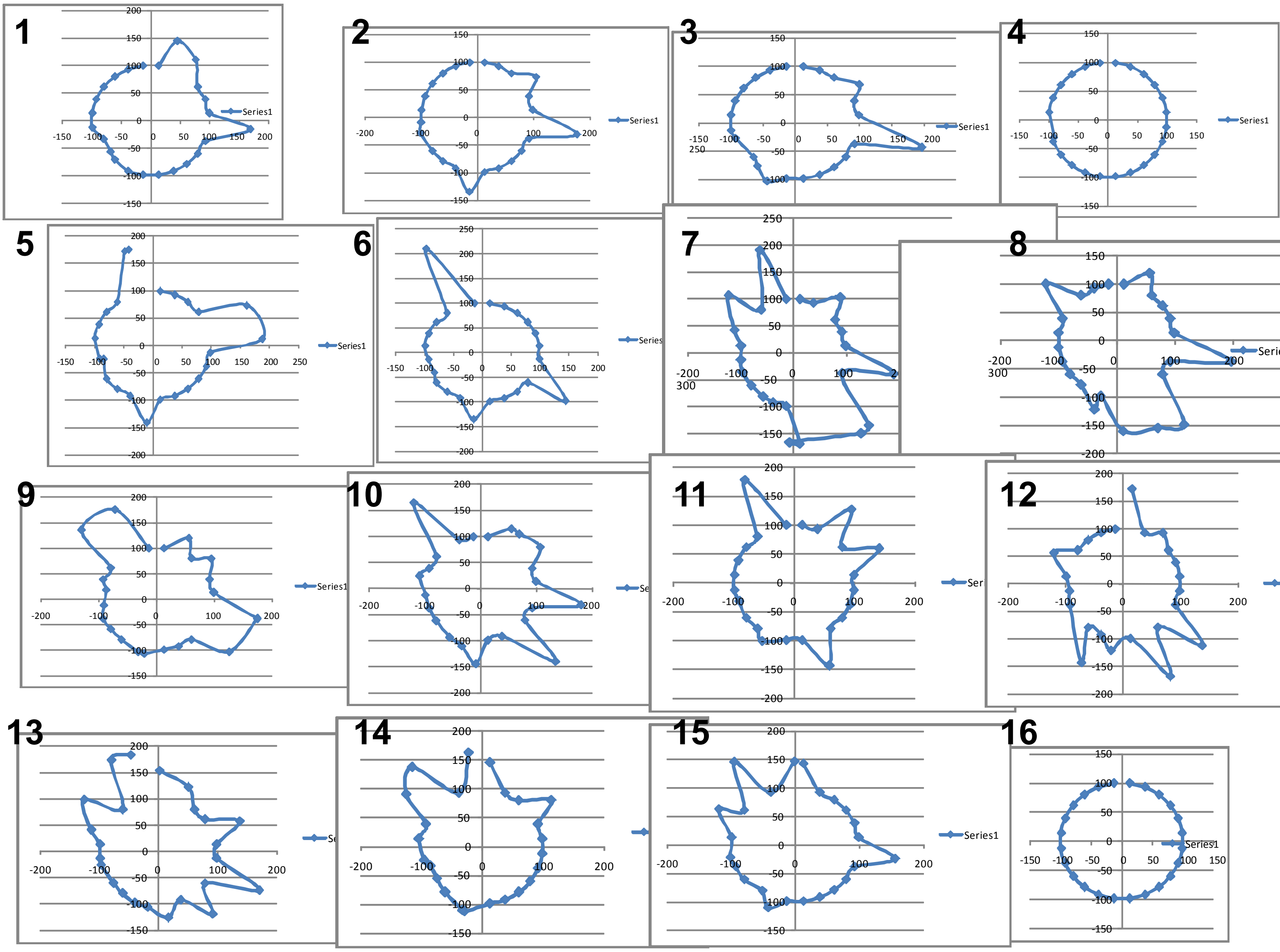

Figure 7. Pictorial dowsing reactions of the 16 practitioners

An easier way of comparing the performances of the practitioners has been devised, to supplement the similarity measures of the 24 GPS bar codes. This is a pictorial representation (Figure 7) where the centre of area coordinates are subtracted from the GPS coordinates. When there is no dowsing reaction in a segment, instead of a point being plotted at the centre of area a radial position along the circumference of an artificial circle is substituted. It must be emphasised that the radius of this artificial circle is arbitrary, and the circle bears no relationship to the actual track around the Ario Bowl. Thus if no dowsing reactions have been obtained just the artificial circle results (see practitioner 16 at the bottom right hand corner of Figure 7). Quite dramatic “spikes” result for valid dowsing reactions, and from the position of these the similar dowsing performances can be seen easily.

Table 1 is the bar codes Similarity Matrix for the Ario data. From this the Dendrogram (Figure 8) and Minimum Spanning Tree (Figure 9) can be derived. It is encouraging that for those practitioners (Martin Laverty, John Wilcock) who undertook more than one run, the multiple runs appear in tight groups, i.e. the runs were consistent and repeatable. Mike Hopley and Rosa Clements also form a group, and John Pybus and Peter Eastoe form another group. The practitioners may be classified as follows:

- Good performance: Rosa Clements (RC), Mike Hopley (MHo), Martin Laverty (ML1, ML2, ML3), John Wilcock (JW1, JW2)
- Partial results: Peter Eastoe (PE), Tom Evans (TE), Geoff O’Dell (GO), John Pybus (JP)
- Sparse results: Paul Windle (PW), Gareth Phillips (GP), Harvey Smith (HS)
- Minimal results: Martin Hicks (MHi), Gavin Lowe (GL)

Thus of the 13 practitioners (only two of whom had significant previous experience), eleven (84% of the total) produced useable dowsing results, of which eight (61% of the total) seemed to have some significance, figures comparable to previous surmises about the percentage of persons in the general population who are able to dowse. This might indicate that a latent ability survives from evolution, perhaps an ability to find water, or to use the earth’s magnetic field for navigation?

1	100	53.37476	48.92461	48.92461	34.06195	41.02322	37.44568	41.02322	30.84359	41.02322	44.83227	24.81906	37.44568	27.76849	30.84359	53.37476
2	53.37476	100	51.46944	48.92461	43.21285	53.11565	31.83686	36.01293	27.33761	31.68646	40.28313	16.5073	35.10446	34.94651	35.10446	41.02322
3	48.92461	51.46944	100	38.46706	34.06195	40.40776	24.72263	37.44568	38.60429	43.08637	37.31196	21.42295	33.95203	43.08637	48.78277	21.98105
4	48.92461	48.92461	38.46706	100	38.46706	50.97532	29.77321	35.03012	16.40731	18.26142	40.65202	5.552671	39.77165	20.96575	36.26432	70.51161
5	34.06195	43.21285	34.06195	38.46706	100	57.43118	27.66812	24.81906	28.76952	23.52872	48.76092	33.40254	37.32981	39.38693	33.95203	21.98105
6	41.02322	53.11565	40.40776	50.97532	57.43118	100	32.91508	30.31799	39.17928	27.26581	53.16287	33.18813	43.46648	36.8659	32.91508	34.06195
7	37.44568	31.83686	24.72263	29.77321	27.66812	32.91508	100	63.68393	29.58483	30.0984	44.26931	31.36743	37.44568	21.31975	27.76849	19.24271
8	41.02322	36.01293	37.44568	35.03012	24.81906	30.31799	63.68393	100	25.7803	39.38693	53.19551	36.75097	37.32981	32.59444	37.32981	27.76849
9	30.84359	27.33761	38.60429	16.40731	28.76952	39.17928	29.58483	25.7803	100	53.27346	37.34346	33.80846	47.23274	53.27346	39.5521	6.749519
10	41.02322	31.68646	43.08637	18.26142	23.52872	27.26581	30.0984	39.38693	53.27346	100	34.88497	40.36104	43.90095	48.92461	47.92006	11.53483
11	44.83227	40.28313	37.31196	40.65202	48.76092	53.16287	44.26931	53.19551	37.34346	34.88497	100	42.25356	44.26931	38.31383	40.49628	34.06195
12	24.81906	16.5073	21.42295	5.552671	33.40254	33.18813	31.36743	36.75097	33.80846	40.36104	42.25356	100	41.63835	52.53994	38.02529	0
13	37.44568	35.10446	33.95203	39.77165	37.32981	43.46648	37.44568	37.32981	47.23274	43.90095	44.26931	41.63835	100	43.90095	48.92461	27.76849
14	27.76849	34.94651	43.08637	20.96575	39.38693	36.8659	21.31975	32.59444	53.27346	48.92461	38.31383	52.53994	43.90095	100	47.92006	9.110674
15	30.84359	35.10446	48.78277	36.26432	33.95203	32.91508	27.76849	37.32981	39.5521	47.92006	40.49628	38.02529	48.92461	47.92006	100	24.81906
16	53.37476	41.02322	21.98105	70.51161	21.98105	34.06195	19.24271	27.76849	6.749519	11.53483	34.06195	0	27.76849	9.110674	24.81906	100
	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16

Table 1. Bar Codes Similarity Matrix for the Ario data

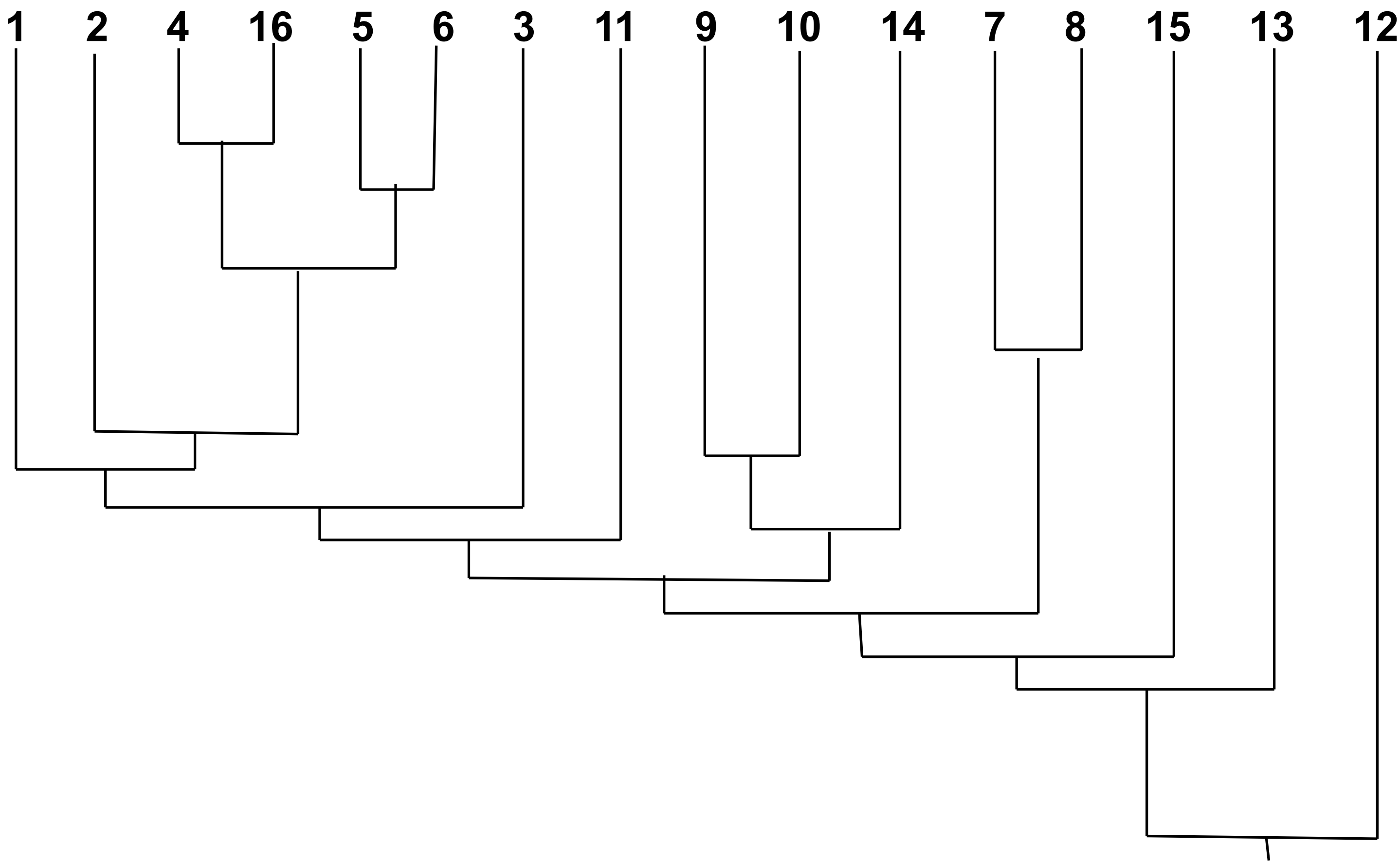

Figure 8 . Dendrogram of the Ario data

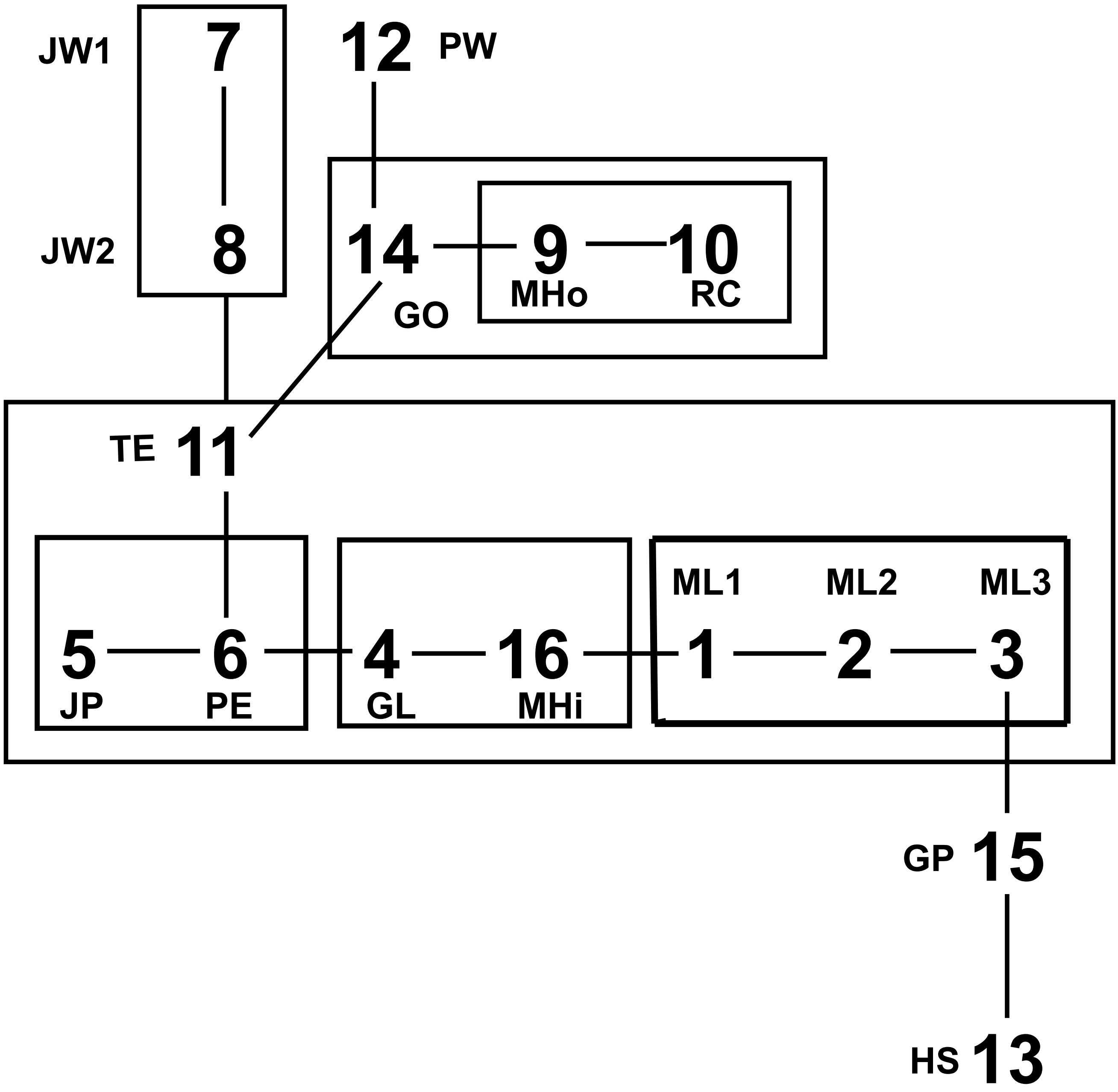

Figure 9 . Wroclaw Diagram for the Ario data (refer to Figure 8 to see the formation of groups)

Conclusion

In conclusion, it can be said that the results appear to be non-random, and for those practitioners who undertook more than one run the results appear to be consistent and repeatable (since they group together in the cluster analysis). However, at 16 runs the sample available was not large, certainly not large enough (at least 20 samples) to satisfy statistical significance tests. The experiment will repay repeating with a larger group, and more individual repeats. It is suggested that an independent, non-participant, Data Manager collect and inspect the data on completion in future; otherwise the methodology seems a sound basis for future tests.

France (1991) concluded "the jury is still out" on the utility and validity of dowsing. The authors believe that dowsing is a useful tool for locating sites of interest to cavers but that, as for any human senses, not all users are as receptive to the same influences. They also believe that this Ario dowsing exercise has been an innovative and useful attempt to quantify dowsing reactions by statistical analysis, and the approach deserves further attention. These hypotheses are published for the record, and are entitled to stand until disproved.

References:

France, S., 1991, "Jury still out in dowsing case", South Wales Caving Club Newsletter 109 (Summer 1991), 6–9

Lock, G.R. and J.D. Wilcock, 1987, Computer archaeology, Shire Publications Ltd, Princes Risborough

Wilcock, J.D., 1991, "Dowsing the Picos", in Proc. Oxford University Cave Club 13 (2005), 70-73

Appendix 1. An explanatory example of the Weighted Pair Group Average Link Cluster Analysis algorithm

Weighted pair group average link cluster analysis

	1	2	3	4	5	6	7	8	9	10
1	10	20	30	40	50	60	70	80	90	100
2	100	90	80	70	60	50	40	30	20	10
3	10	15	20	25	30	35	40	45	50	55
4	55	50	45	40	35	30	25	20	15	10
5	5	15	25	35	45	55	65	75	85	95
6	15	14	13	12	11	10	9	8	7	6
7	100	92	84	76	68	60	52	44	36	28
8	60	54	48	42	36	30	24	18	12	6

Table 2. Test data Incidence Matrix 8 items, 10 properties

Table 2 is a simple set of test data to illustrate the algorithm. This so-called Incidence Matrix contains 8 items, each with property values for 10 properties. The first step is usually to calculate the 8 x 8 Similarity Matrix, in which each item is compared with all the other items. A suitable similarity measure must be employed, in this case:

$$100\left(1 - \sqrt[2]{\frac{\sum_{n=1}^{q}(Pin-Pjn)^2}{MAX\left(\sum_{n=1}^{q} Pin^2, \sum_{n=1}^{q} Pjn^2\right)}}\right)$$

where q is the number of properties (in the example q=10)

MAX = the greater of the two operands in the brackets

Pin are the property values for item i (n varies from 1 to q, while i varies from 1 to 8 in the example)
Pjn are the property values for item j (n varies from 1 to q, while j varies from 1 to 8 in the example)

The numerator of the fraction is a distance measure (root of the sum of the squares of the property differences)

The denominator of the fraction is a normalising feature which ensures that the value of the resultant fraction is between 0 and 1

The distance measure is subtracted from 1 to convert the distance measure into a similarity measure

Multiplication by 100 converts the similarity value between 0 and 1 into a percentage value between 0 and 100.

100	7.41799	56.98083	21.66505	91.94177	12.0434	22.82564	17.8851
7.41799	100	21.66505	56.98083	7.067962	17.05893	84.29841	60
56.98083	21.66505	100	19.1628	60.73993	21.34799	28.15909	15.12253
21.66505	56.98083	19.1628	100	19.35411	30.14867	51.97454	92.16881
91.94177	7.067962	60.73993	19.35411	100	12.28035	21.23081	15.02322
12.0434	17.05893	21.34799	30.14867	12.28035	100	15.95103	28.30138
22.82564	84.29841	28.15909	51.97454	21.23081	15.95103	100	53.63564
17.8851	60	15.12253	92.16881	15.02322	28.30138	53.63564	100

Figure 10. Similarity Matrix 8 x 8

Figure 10 shows the 8 x 8 Similarity Matrix for the 8 x 10 test data Incidence Matrix in Table 2. Note that the values on the central diagonal, where the items are compared to themselves, are all 100%. Also the values in the upper half of the matrix are a mirror reflection of the values in the lower half of the matrix, and so if storage is at a premium, as it may well be in the case of hundreds of items, only the values of the lower half matrix less the central diagonal need to be stored. At this stage the Minimum Spanning Tree can be derived manually. To do this the largest two entries in each column (boxed in red above) are used, but to resolve ambiguities it may be necessary to use the third largest entry in each column (boxed in blue above), or even lower values for very large matrices. Using a graphical representation, the items are linked by lines with the most similar two other items, each link labelled with its similarity value. The procedure is repeated until all the columns of the Similarity Matrix have been so processed. It is normal for closed loops to develop. If all the items have then been connected into just one mass it is not necessary to take more information from the Similarity Matrix. However, if two or more distinct groups of items have developed it will be necessary to use the third largest entries (marked blue above) or even fourth largest, etc. until all items are linked into just one mass. Then for each closed loop within the linkage the weakest link is deleted, and this procedure continues until no closed loops remain. The resultant diagram is the Minimum Spanning Tree: it is normally branched, and must contain no closed loops. If only a single chain with no branches has resulted, this will be a *Linear Seriation* of the items.

Continuing with the clustering algorithm, the next stage is normally to derive the Dendrogram. Using all the entries in the Similarity Matrix, and beginning with 100%, the similarity (phenon) level is successively reduced until single items or pre-formed groups of items coalesce. The similarity level is noted at this point. New property values are then calculated for each of the new groups: in the weighted pair group method the values are weighted according to the number of items in a joining item or group, e.g. if group i has r items and group j has s items, each having q properties, the new properties of group i will be:

$$Pin = \frac{r \; x \; Pin + s \; x \; Pjn}{r+s} \qquad \text{for } n=1 \text{ to } q$$

and group j will be deleted. The Similarity Matrix then has to be recalculated each time a new group is formed, using the new group properties against all the single items or groups which still exist (these are the phenons at the current similarity level). The procedure continues, successively reducing the similarity level until all the items or groups coalesce into just one group, when the dendrogram procedure terminates. Figure 11 shows the Dendrogram for the test data.

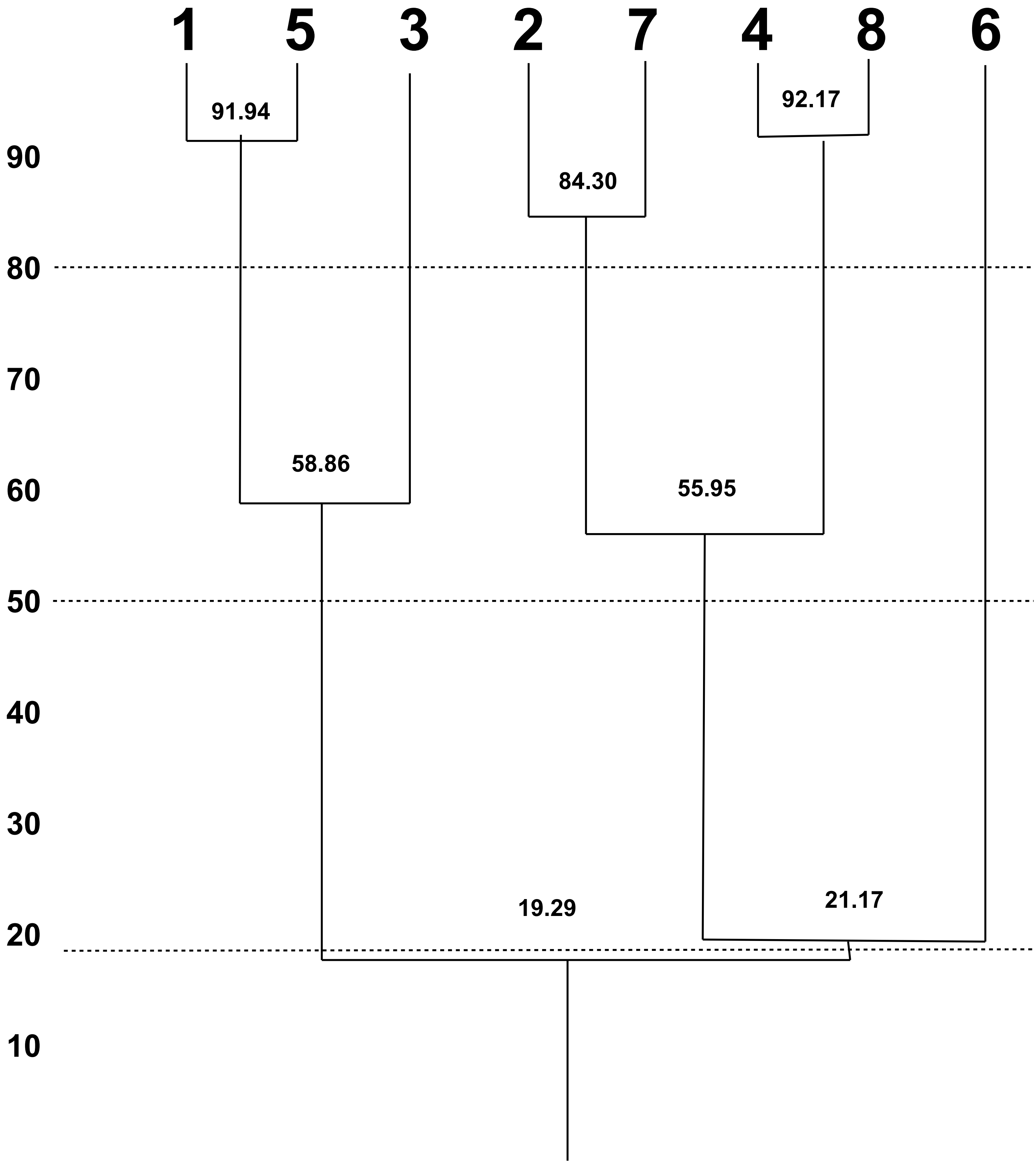

Figure 11. Dendrogram of the test data

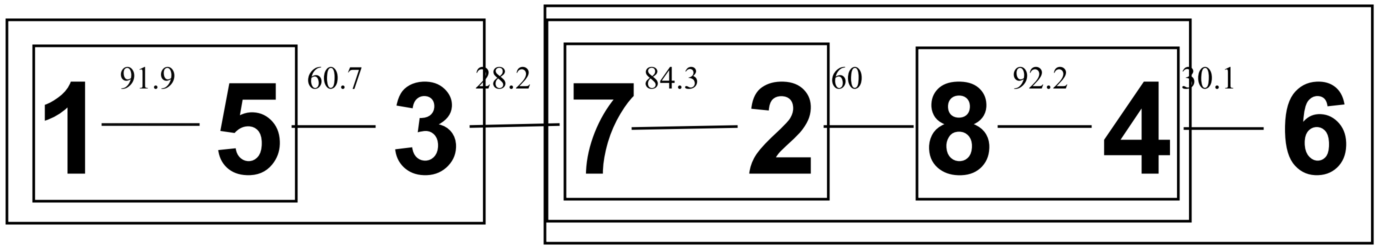

Figure 12. Minimum Spanning Tree with Wroclaw Diagram groups for the test data

The next stage is to create a Minimum Spanning Tree for the data. The links on Figure 12 show the Minimum Spanning Tree for the test data, each link being labelled with the similarity level at which the link forms. In the case of the test data a *Linear Seriation* has resulted. However, the Minimum Spanning Tree will more normally have a branched structure.

Adding loops to the Minimum Spanning Tree as in Figure 12, a Wroclaw Diagram may also be created. The loops are placed around any significant groups that have been detected. In Figure 11 the 80% , 50% and 20% phenons have been indicated by dotted lines: by 80% item 1 has joined 5, 7 has joined 2, and 8 has joined 4; by 50% group 1 consists of 1, 3 and 5, while group 2 consists of groups 2 & 4 (items 2, 4, 7 & 8); and by 20% item 6 has joined group 2. Note that on Figure 12 the similarity values indicated on the links refer to the highest value for a pair of items, e.g. 2 is 60% similar to 8, but because of the recalculation of similarities once a group is formed, the larger 2,4,7,8 group does not form until 55.95% (see Figure 11).

Some suitable general texts where these topics are discussed are Hodson, Kendall & Tautu (1971); Allsworth-Jones & Wilcock (1974); Celoria & Wilcock (1975); Doran & Hodson (1975); Hodder & Orton (1976); Orton (1982); Martlew (1984); Richards & Ryan (1985); Cooper & Richards (1985); Reilly & Rahtz (1992); and Fletcher & Lock (1994).

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Appendix 2: The Ario Data

The 16 x 48 GPS Incidence Matrix for the Ario Experiment is given in Table 3, and the 16 x 24 presence/absence “bar codes” Incidence Matrix is given in Table 4. Since these 24-bit binary (base 2) numbers are difficult to remember and to write down, the equivalent 8-digit octal (base 8) and 6-digit hexadecimal (base 16) representations are also given; a decimal count of the number of reactions obtained by the practitioner completes the data. The 16 individual runs were as follows:

1, 2, 3. Martin Laverty (ML1, ML2, ML3)
4. Gavin Lowe (GL)
5. John Pybus (JP)
6. Pete Eastoe (PE)
7, 8. John Wilcock (JW1, JW2)
9. Mike Hopley (MHo)
10. Rosa Clements (RC)
11. Tom Evans (TE)
12. Paul Windle (PW)
13. Harvey Smith (HS)
14. Geoff O’Dell (GO)
15. Gareth Phillips (GP)
16. Martin Hicks (MHi)

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16 48

4014 9436 4059 9580 4090 9546 4014 9436 4014 9436 4014 9436 4183 9420 4014 9436
4014 9436 4014 9436 4014 9436 4014 9436 4014 9436 4014 9436 3953 9365 3946 9379
3934 9402 4014 9436 4014 9436 4014 9436 4014 9436 4014 9436 4014 9436 4014 9436

4014 9436 4014 9436 4014 9436 4119 9509 4014 9436 4014 9436 4192 9405 4014 9436
4014 9436 4014 9436 4014 9436 4014 9436 4000 9301 4014 9436 4014 9436 4014 9436
3913 9408 3914 9427 4014 9436 4014 9436 4014 9436 4014 9436 4014 9436 4014 9436

4014 9436 4014 9436 4014 9436 4114 9503 4014 9436 4014 9436 4211 9392 4014 9436
4014 9436 4014 9436 4014 9436 4014 9436 4014 9436 3971 9332 3956 9359 3950 9375
3922 9408 3915 9422 4014 9436 4014 9436 4014 9436 4014 9436 4014 9436 4014 9436

4014 9436 4014 9436 4014 9436 4014 9436 4014 9436 4014 9436 4014 9436 4014 9436
4014 9436 4014 9436 4014 9436 4014 9436 4014 9436 4014 9436 4014 9436 4014 9436
3923 9405 4014 9436 4014 9436 4014 9436 4014 9436 4014 9436 4014 9436 4014 9436

4014 9436 4014 9436 4014 9436 4014 9436 4176 9509 4203 9448 4014 9436 4014 9436
4014 9436 4014 9436 4014 9436 4014 9436 4004 9295 4014 9436 4014 9436 4014 9436
3930 9411 3923 9412 4014 9436 4014 9436 4014 9436 4014 9436 3966 9608 3973 9611

4014 9436 4014 9436 4014 9436 4014 9436 4014 9436 4014 9436 4014 9436 4159 9338
4014 9436 4014 9436 4014 9436 4014 9436 3999 9301 4014 9436 4014 9436 4014 9436
3931 9395 3921 9422 4014 9436 4014 9436 4014 9436 4014 9436 3917 9645 4014 9436

4014 9436 4014 9436 4103 9538 4014 9436 4014 9436 4014 9436 4204 9397 4014 9436
4157 9301 4142 9286 4007 9270 4026 9267 4014 9436 4014 9436 3957 9355 4014 9436
3918 9400 4014 9436 4014 9436 3903 9478 3892 9542 4014 9436 3951 9626 4014 9436

4014 9436 4071 9555 4014 9436 4014 9436 4014 9436 4014 9436 4211 9398 4014 9436
4014 9436 4130 9280 4085 9274 4014 9436 3987 9313 4014 9436 4014 9436 4014 9436
4014 9436 4014 9436 4014 9436 4014 9436 3893 9536 4014 9436 4014 9436 4014 9436

4014 9436 4070 9555 4014 9436 4109 9515 4014 9436 4014 9436 4189 9398 4014 9436
4140 9333 4014 9436 4014 9436 4014 9436 3993 9329 3982 9333 4014 9436 3935 9377
4014 9436 3923 9424 3927 9454 4014 9436 4014 9436 3884 9571 3942 9611 4014 9436

4014 9436 4069 9550 4083 9540 4121 9515 4014 9436 4014 9436 4194 9404 4014 9436
4014 9436 4148 9296 4014 9436 4014 9436 4005 9291 3980 9325 3958 9342 3934 9374
4014 9436 4014 9436 3904 9460 4014 9436 4014 9436 3894 9600 4014 9436 4014 9436

4014 9436 4014 9436 4109 9562 4014 9436 4155 9495 4014 9436 4014 9436 4014 9436
4014 9436 4014 9436 4072 9293 4014 9436 4014 9436 3961 9335 4014 9436 4014 9436
3923 9404 4014 9436 4014 9436 4014 9436 4014 9436 4014 9436 3932 9613 4014 9436

4016 9589 4065 9558 4014 9436 4014 9436 4152 9493 4014 9436 4014 9436 4186 9362
4014 9436 4106 9317 4014 9436 4031 9310 3996 9330 3974 9338 4014 9436 3938 9376
3917 9410 4014 9436 4014 9436 3900 9477 3888 9534 4014 9436 3934 9609 3967 9619

4030 9608 4014 9436 4084 9528 4014 9436 4014 9436 4014 9436 4014 9436 4014 9436
4153 9324 4014 9436 4097 9268 4014 9436 3993 9315 4014 9436 4014 9436 3942 9293
4014 9436 3921 9423 4014 9436 3893 9492 4014 9436 4014 9436 4014 9436 4014 9436

4027 9581 4014 9436 4014 9436 4128 9516 4014 9436 4014 9436 4014 9436 4014 9436
4014 9436 4014 9436 4014 9436 4014 9436 3985 9323 3982 9325 4014 9436 3940 9380
3929 9402 3919 9412 3910 9449 4014 9436 3889 9526 3899 9573 4014 9436 3992 9598

4027 9579 4014 9436 4014 9436 4014 9436 4014 9436 4014 9436 4170 9412 4014 9436
4014 9436 4014 9436 4014 9436 4014 9436 4014 9436 3972 9325 3963 9355 4014 9436
4014 9436 3913 9414 4014 9436 3895 9499 4014 9436 3919 9582 4014 9436 4013 9583

4014 9436 4014 9436 4014 9436 4014 9436 4014 9436 4014 9436 4014 9436 4014 9436
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4014 9436 4014 9436 4014 9436 4014 9436 4014 9436 4014 9436 4014 9436 4014 9436
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Table 3. Ario Incidence Matrix 16 sets of 48 GPS coordinates

	16 24				
1	011000100000000110000000	30400600	620180	5	ML1
2	000100100000100010000000	04404200	120880	4	ML2
3	000100100000011111000000	04403700	1207C0	7	ML3
4	000000000000000001000000	00000100	000040	1	GL
5	000011000000100011000011	03004303	0C08C3	7	JP
6	000000010000100011000010	00204302	0108C2	5	PE
7	001000101111000000001010	10570012	22F00A	8	JW1
8	010000100111010000001000	20472010	427408	7	JW2
9	010100111000110101100110	24706546	538D66	12	MHo
10	011100100100111100100100	34447444	724F24	11	RC
11	001010000010010010000010	12022202	282482	6	TE
12	110010010101110110011011	62256633	C95D9B	14	PW
13	101000001010100101010000	50124520	A0A950	8	HS
14	100100000000110111101101	44006755	900DED	11	GO
15	100000100000011001010101	40403125	820655	8	GP
16	000000000000000000000000	00000000	000000	0	MHi

Table 4. Ario Incidence Matrix: 16 sets of 24-digit binary, 8-digit octal, and 6-digit hexadecimal Bar Codes showing the Presence/Absence of dowsing reactions in the 24 segments, plus a decimal count of the number of positive reactions obtained by each practitioner